STUDIES UPON THE CEREBRAL CORTEX IN THE NORMAL HUMAN BRAIN AND IN DEMENTIA PARALYTICA.

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Technique. Turning to the technique employed in this work, first will be described a method used in transporting material considerable distances in the minimum amount of space, and preparing the same in the shortest possible time.

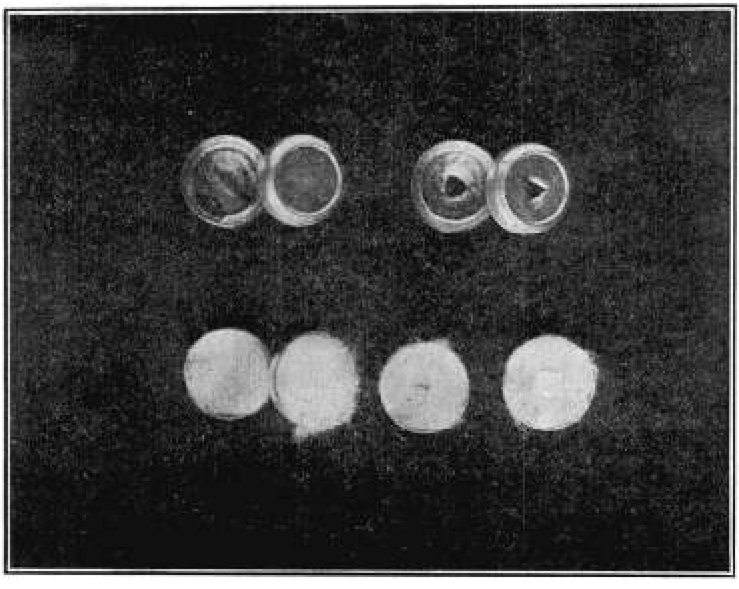


Fig. A.

On several occasions the writer was enabled to secure more than one brain at the same time, and at a considerable distance from the laboratory. It was desired to place small blocks from various parts of each of the brains in various fixative media in the shortest possible time, and to put them into the smallest possible space for transportation. The smallest size of tin boxes known as "Miller's patent seamless box" (Fig. A) were secured at trifling cost at Eimer & Amend's, in New York city; though any small box would answer the purpose. These measured but 2.5 c. c. in diameter and 1.25 c. c. in depth. One gross of these boxes occupy only a space of 15 c. c. square by 5 c. c. in depth. By piercing a hole in both the cover and bottom of these boxes a free circulation of the fixative medium is secured—as mentioned, any other small box or phial admitting of the free circulation of the fixative medium could be used; but these chanced to be the most convenient and available receptacles to the writer. By placing a bit of absorbent cotton or cheesecloth in both the bottom of the box and in the cover the specimen is perfectly protected. A square box of black pins (Fig. B), such as can be secured at any drygoods store at trifling cost, was purchased. Small squares of cardboard

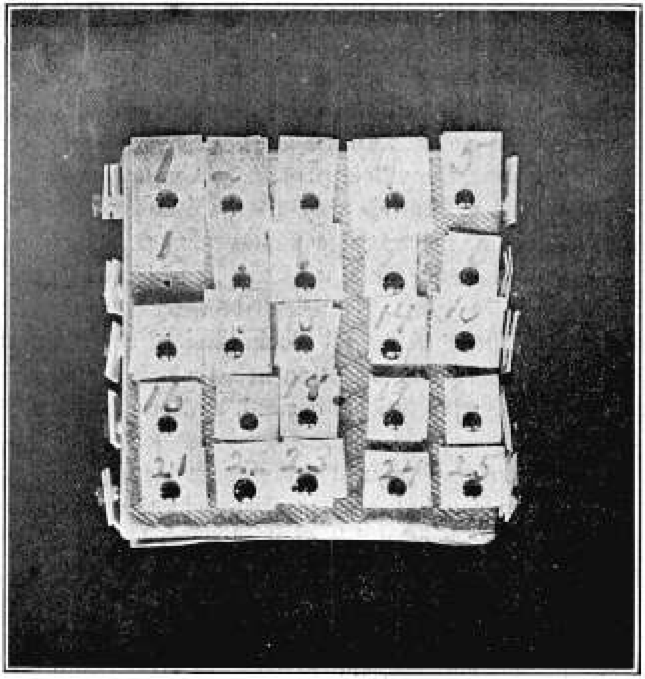


Fig. B.

were cut out and numbered in duplicate, using a lead pencil. Each number, with its single duplicate, was placed upon a pin and returned to its position in the box. The various fixative fluids desired were carried in small glass jars with ground glass covers. All these preparations are made in advance so that at the autopsy, upon removing the brain, small pieces can be taken from any part of the cortex, each one placed in a separate small tin box with a number from one of the pins. The other or duplicate number is left upon the pin, and the latter thrust into the space on the brain surface from which the block was taken (Plate I, Fig. 1). The small tin box is then thrown into whatever fixative fluid is desired, and the fluid enters and fills up the interior by means of the openings above described, the whole process taking less time than required in explanation. In this way a large number of blocks can be taken from one or more brains without any possibility of confusion, and in a minimum amount of time, and likewise take up a minimum amount of space, requiring no writing or labeling of specimens at the time. After all blocks desired are removed the brain is carefully placed upon cotton in a tin pail of the required size in whatever fixative fluid is desired, and other brains can be treated similarly.

At the laboratory subsequently the exact locality from which blocks were taken can be noted at leisure in the most accurate manner. The writer has by this method taken blocks from various parts of two separate brains, placed them in half a dozen different fixative fluids, and packed them up, together with the two brains in tin pails of suitable diameter, placing everything in a hand bag of medium size, and carried the same many miles on the train without the slightest inconvenience or knowledge by others of the contents of the hand-bag. The fixative agents employed in this work were alcohol absolute, alcohol 95 per cent, formalin 10 per cent solution (40 per cent formaldehyde, 1 part by volume, water 9 parts by volume), Van Gehuchten's fluid (alcohol absolute 60, chloroform 30, and glacial acetic acid 10 parts by volume), and Lang's solution (mercuric chloride 5 grams, sodium chloride 6 grams, acetic acid 5 grams, and water 100 grams). The most satisfactory results have come from fixation in Van Gehuchten's fluid, and the alcohols. In the employment of the latter more or less shrinkage results, but this can be recognized, and the chromatic substance within the cell is usually well marked. Van Gehuchten's fluid was used as follows: Small blocks, not more than .3 to .5 c. c. in thickness, were immersed in Van Gehuchten's fluid and left for twelve hours. They were then placed in 95 per cent alcohol, where they remained until desired for use. No changes in the contour of the cells were observed to result, and the chromatic substance in these cells was well shown in the subsequent staining. Blocks to be imbedded were then placed in absolute alcohol, and, for the paraffin method, transferred to xylol, and left in the latter for several hours till thoroughly permeated. They were then placed in paraffin—melting point about 50° C., for from 45 minutes to one hour, and then transferred to another paraffin bath of the same melting point for the same length of time, so as to secure complete penetration and the removal of all xylol. The blocks were then imbedded and subsequently sectioned by a Minot microtome serially. The sections were made varying in thickness from 2 to 15 microns, those from 6 to 10 microns being found best for study of the arrangement and internal structure of the cells. The celloidin method was also employed, but it was more difficult to secure thin sections when desired, and especially to arrange them serially. A thin smear of egg albumin was placed upon a perfectly clean slide, several consecutive sections placed upon the same, and then a small quantity of water by means of a pipette allowed to flow under the sections. This was gently warmed upon the water bath or over an alcohol lamp until the sections were perfectly flattened out. The water was drawn off and the sections allowed to dry. This treatment permitted all subsequent manipulations with the sections upon the slides, without their floating off or becoming disturbed or injured. The slides were then placed in xylol to dissolve out all paraffin and run down in successive grades of alcohol from absolute alcohol to 30 per cent alcohol, and from the latter immersed in water. The sections were then stained upon the slide by means of an aqueous solution of methylene blue, as given by Nissl (methylene blue, 3.75 grams; Venetian soap, 1.75 grams, and distilled water 1,000 c. c.), or by a 1 per cent aqueous solution of methylene violet or a 1 per cent aqueous solution of thionin. A counter stain of erythrosin was used in some cases after treatment with methylene blue, giving the achromatic substance a pink color in contrast to the blue color of the chromatic substance. The routine method was to gently heat the slide covered with the stain for two minutes over an alcohol lamp, keeping the slide in constant motion, and only allowing it to become sufficiently heated so that the steam would come from the surface, but no bubbling of the dye in solution. The dye was then gently washed off, the slide immersed in water, and then run up into 30, 50, 70, 80, 95 per cent, alcohol, absolute alcohol plus xylol equal parts, xylol, and finally mounted in xylol-damar. Some slides were placed, after immersion in water following the staining process, in anilin-oil 10 parts, absolute alcohol 90 parts, and subsequently treated as described by Nissl, and finally mounted in benzene-colophonium. The first method, however, gave the most satisfactory results in the hands of the writer, and which, as seen, embodies various modifications of the original Nissl method. Sections prepared in the routine method above described have been frequently examined under the microscope, also frequently exposed to sunlight, and at times to the powerful rays of the electric arc in the photomicrographic work, but were in nowise faded or injured after a period of two years from the time of preparation.

In the micrographic work the most painstaking care was employed in every detail of the work. Achromatic objectives of various power with compensating eye-pieces in different combinations were used so as to produce different magnifications up to 1,400 diameters. Oil-immersion lenses were not used, as the above combination secured the greatest possible depth under such high powers. The time of exposure varied from a few seconds in the low power photomicrographs to five minutes in some of those magnified 1,400 diameters.

Material. Some twenty brains were secured, and sections made from various parts of them all and studied in connection with this article. Three brains of cases electrocuted at Ossining, and in which the autopsy occurred immediately afterwards and the material placed in various fixative media, were secured. The photomicrographs representing the practically normal brain histologically in the first part of this article were taken from one of these brains, marked A (Plate I, Fig. 1), a man thirty-six years of age who had been confined in Sing-Sing State Prison for over two years and leading the regular routine prison life during that period. The autopsy was held immediately after death by electrocution. The body was well nourished, and no pathological condition of the central nervous system or other organs was found. Small blocks, .3 to .5 c. c. in thickness, from various convolutions of the brain were placed in the various hardening or fixative agents described above, and the brain itself immersed in 95 per cent alcohol. The blocks were subsequently imbedded in paraffin, sectioned serially, stained, differentiated, and mounted as already described.

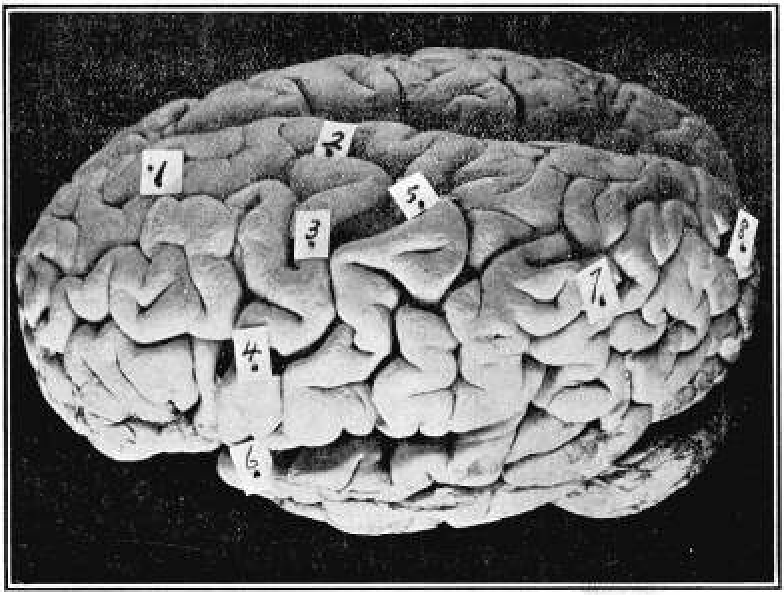


Plate I, Fig. 1.

Brains from three cases of dementia paralytica were also secured and studied. Sections from the one marked B (Plate X, Fig. 29) were used to illustrate this article in its pathological portion. The paralytic dement from which brain B was taken was a lawyer, had a collegiate education, was single, no history of syphilis, and family history negative. Was native of the United States. The disease began at about the age of twenty-eight years with the usual change of character, followed by grandiose ideas and maniacal excitement. Asylum treatment for over a year caused his symptoms to clear up sufficiently so that he was discharged. For nearly two years he was in a fairly quiet condition. He then broke out in a long period of excitement, lasting over a year, followed by terminal dementia lasting for one and a half years before death, which latter was uncomplicated. Duration of the disease was thus over five and a half years, during which period there was a remission lasting two years, in which he did not require asylum treatment. There was contracture of both arms and legs for three months preceding death. Mentally he was a little brighter during that time. At death the body was immediately placed upon ice, and the autopsy performed fifteen hours later. The body weighed 78 pounds at death and was flexed. Two small cavities, each the size of a pea, were found in the apex of the right lung. The lymphatics were somewhat enlarged. Heart was atrophied. There was meningeal thickening. The ependyma in the posterior part of the floor of the fourth ventricle was very slightly granular. The membranes were anemic, and there was no edema or fluid. The convolutions, especially in the region of the central convolutions, are widely separated from one another; but, as will be described later, this is largely due to mechanical causes in subsequent fixation. In addition to these brains over a dozen were secured from other sources, mostly from the New York City Morgue, of persons who had committed suicide or died suddenly from accident or homicide, with autopsy performed within a few hours after death.

Normal Cortex. The descriptions and plates herein contained, and illustrating the normal human cortex, are not intended to give the idea of being in any way a complete exposition of such a vast subject; but it has been the aim to give photomicrographs with accompanying descriptions of typical sections and cells from various regions of the cortex, as a basis of comparison with sections taken from corresponding regions of the cortex in a case of dementia paralytica. Neither is this contribution intended to be in the nature of an atlas, being much too limited in scope for such a work; but to illustrate as far as practicable the structures found in what can be considered a fairly normal brain, with the conditions found in a brain of one dying from dementia paralytica. Various regions of the normal cortex from brain A, one of the electrocuted cases (Plate I, Fig. 1), with its accompanying plates will be first described, and then will follow a like description of the corresponding region with its accompanying illustrations of the brain of the case of dementia paralytica, brain B (Plate X, Fig. 29). Plate I, Fig. 1, above referred to, shows the left hemisphere of Brain A, natural size; a normal brain, with well marked convolutions and sulci. The small pieces of cardboard with their

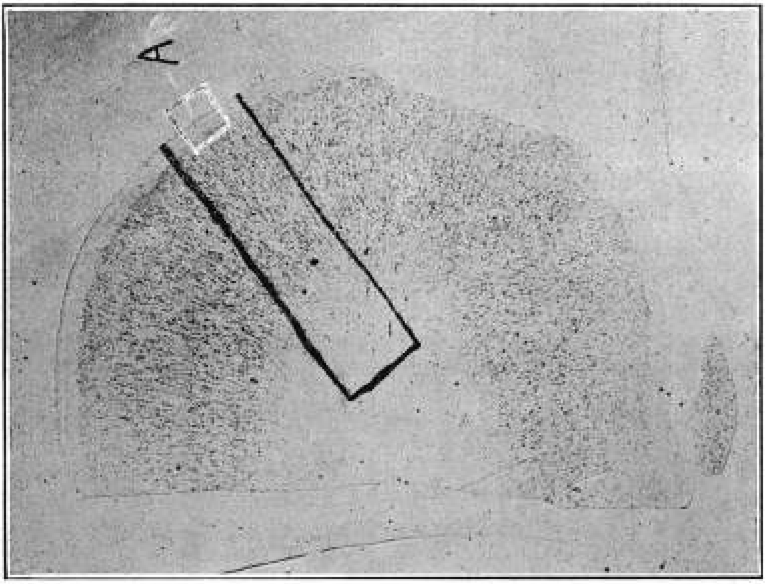
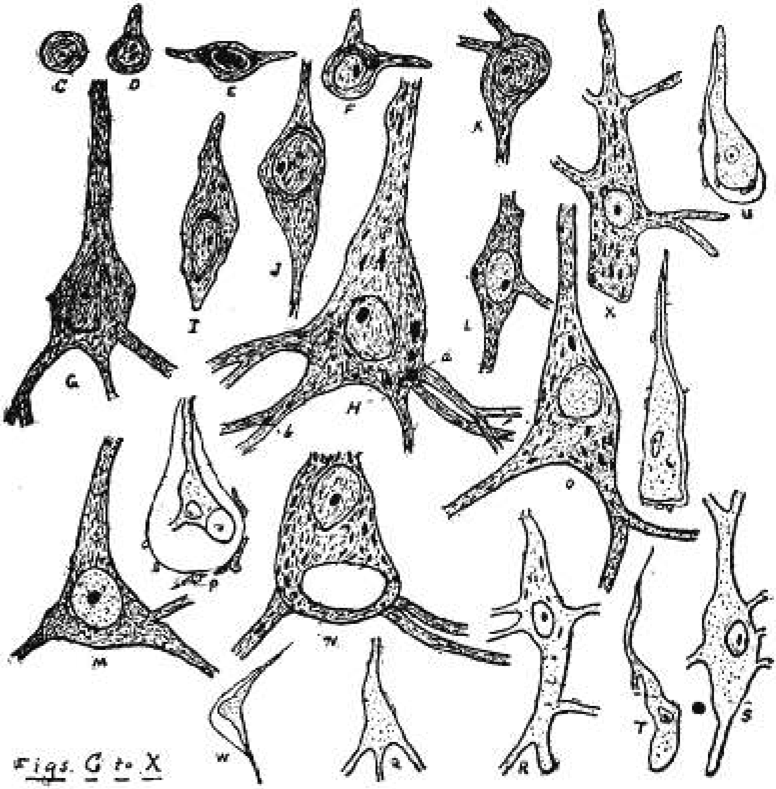


Plate I, Fig. 2.

contained figures show the particular point from which the subsequent blocks were taken, and also illustrate the method of exact localization of blocks described under the heading of technique.

Frontal Region.—Turning now to the several cortical regions, various portions of the first, second and third frontal convolutions were examined in different brains, and typical of this region is the section shown in Plate I, Fig. 2, which, with minor modifications, is similar to that of all portions of this region, and will now be described in detail. The block from which this section was taken comprised a part of the external surface of the first, or superior frontal convolution, including the entire width of the gyrus for a distance of .4 cm., and taken from the position shown by the figure 1, Plate I, Fig. 1. The gyrus at this point measures .6 cm. in width, so that the actual size of this section is .6 cm. in width by .4 cm. in depth, and it is 6 2-3 microns in thickness.

The block at autopsy immediately after death was placed in Van Gehuchten's fluid, where it remained for twelve hours, when it was placed in alcohol 95 per cent until ready for use. It was then imbedded in paraffin, sectioned serially with a Minot microtome, stained for two minutes in warm methylene blue, decolorized in alcohol, cleared in xylol, and mounted in xylol-damar. Plate I, Fig. 2, referred to above, shows the section under a magnification of 14 diameters. The section has been broken in manipulation, but shows the general striated arrangement of the cells radiating outward from the white medullary center to the surface; also the layering of the cortex. The strip of cor-



tex outlined in ink on the plate at *a* is that portion shown in Plate II, Fig. 3, under a magnification of 100 diameters. The outer pale layer, the thicker cellular layers, and the inner medullary white portion can easily be differentiated even with this magnification.

The outer layer is found to be fairly uniform in thickness in this section, but we will find later that there may be a considerable variation, not only in the thickness of this layer, but also of the other layers, and consequently of the entire cortex. The radial arrangement of the cells from the medullary white substance is especially well shown under this magnification, and a more general and comprehensive view of both the normal arrangements and of derangements and disturbances due to pathological changes can be made out under this magnification than by higher powers in which but minute areas are seen. These latter high magnifications are of course also necessary for the complete study of all the details of such variations or pathological changes. Plate II, Fig. 3, magnified 100 diameters, is that portion of the section outlined in ink in Plate I, Fig. 2 at *a*. Decolorization has been carried on here to such a degree as to make many of the cells appear somewhat pale and washed out, and to cause a complete decolorization of many of the neuroglia cells. This, however, admits of a better study of the arrangement of the internal structure of the cells, as a too deep colorization does not sufficiently differentiate the chromophilic granules and network. The outer surface of the cortex is here seen to be smooth and regular. Immediately beneath is the first or superficial layer, pale in color, .25 mm. in thickness, and characterized by a paucity of cells irregularly arranged and appearing upon a colorless background, which we know from sections treated by the Weigert method to be made up of large numbers of densely packed nerve fibers and processes. In the plate are seen for the most part neuroglia cells, but under a high power here and there nerve cells are found, rounded, spindle-shaped, or polygonal in form, with a nucleus filling up almost the entire cell-body, and with no visible dendritic processes, or at most but one or two extending vertically or at right angles to the surface of the cortex. The cell-body contains but a small mass of chromophilic substance, usually forming a narrow band about the nucleus with thickenings where the dendritic processes are given off. The cells with no visible processes of course may have such extending in a direction outside of the plane of the section. Fig. C shows one of these cells containing no visible processes, with a rounded cell-body, a large rounded nucleus almost filling up the same and surrounded by a uniformly thin band of chromatic substance. Fig. D shows another cell from this same region with a single proces vertical to the surface of the cortex. Here again the large rounded nucleus almost fills up the cell-body and is surrounded by a thin band of chromatic substance thickened at the point where the dendritic process is given off, and extending into the same for a short distance. Fig. E shows a similar cell, but with two processes extending in a nearly horizontal direction. The thin chromatic band is here thickened at both extremities. The greatest diameter of the cell in Fig. D is vertical, while in Fig. E it is horizontal, in Fig. C of course being practically uniform. Occasionally cells are seen with one process vertical and the other horizontal, as in Fig. F, this being polygonal in shape. The nuclei in all of these cells are well defined, large, and contain a small amount of chromatin in the form of a poorly differentiated network, and at some point containing a distinct nucleolus. According to Nissl's classification of nerve cells these would be known as karyochrome nerve cells. The neuroglia cells are smaller, rounded or oval in shape, contain a nucleus, and are much more numerous in this layer than the comparatively scarce nerve cells. The second or pyramidal cell layer, to simplify the layering of the cortex to the greatest extent, as previously described, is made to include both the large and small pyramidal cells. This measures in the plate (Plate II, Fig. 3) 1.40 mm. in depth. This layer thus includes the large and small pyramidal cell layers and the ganglionic cell layer of Hammarberg, and the large and small pyramidal cell layers of Golgi and of Cajal. (See Table I.) Hammarberg (1895) in his description of this region states that the layer of small pyramidal cells does not form a distinct layer, but gradually passes over into that of the third layer of large pyramidal cells, so that the two in his division make a layer .80 mm. in depth. He further states that the under border of the third layer is difficult to determine, so that there is no distinct fourth layer. This fourth layer is then described as containing small pyramidal cells less thickly distributed than in the layer above, intermingled with which are some smaller irregular cells, giving the appearance of a region poor in cells; and he notes further that in many places the difference is so slight that it does not make a separate layer. His fifth layer is described as a .70 mm. thick ganglion cell layer, made up of somewhat larger and more closely packed pyramidal cells. These layers,—second, third, fourth and fifth layers of Hammarberg, are all included in this second layer of the writer, and in this section measures about 1.40 mm. in thickness. It is made up of pyramidal cells varying in size in all parts of the layer, so that in any region, excepting a band below the middle portion to be described later, pyramidal cells of different size may be seen in close proximity.

As a rule, however, the larger pyramidal cells are found mostly in the deeper portion of the layer. But here as elsewhere are to be seen the small pyramidal cells interspersed. There are also to be seen some rounded and irregular cells throughout this layer. Just below the middle of this second layer is seen a belt some .30 mm. in width, in which small pyramidal cells decidedly predominate and containing but few larger and medium sized pyramidal cells. This region is comparable to the fourth layer of Hammarberg, but as it contains no elements differing from the region above and below, but simply varies in the relative number and size of the same, it does not seem to the writer worthy the designation of a separate layer with the resulting increase in the number of layers. Both above and below this belt large and small pyramidal cells are intermingled; the large pyramidal cells increasing in proportion from above downward. Fig G (G of Plate II, Fig. 3) shows the details of structure of one of these small pyramidal cells under a high magnification (x 1,300. No. 3 ocular, 1-12 in. oil immersion objective, Leitz). By focussing in different planes the large, broad, apical, dendritic process is seen extending vertically towards the surface of the cortex. It contains chromophilic granules arranged with the long axis parallel to the axis of the cell. The cell-body is in the form of a pyramid with rounded sides. The large nucleus is irregularly oval with the long axis parallel with the long axis of the cell. The nucleolus is centrally located and surrounded by the slightly stained nuclear contents. From the lower portion of the cell-body are given off three dendritic processes, one of which subsequently branches into two processes, at which point a mass of chromatin is seen, one of the so-called "wedges of division" (Versweigungs-Kegln) of Nissl. These dendritic processes contain no chromophilic granules, but at the point where they are given off from the cell-body are found aggregations of chromophilic granules which also surround the nucleus on either side, their long diameter extending in general parallel with the long axis of the cell. Plate II, Fig. 4, is a photomicrograph of this same cell as stated, indicated by the letter G in Plate II, Fig. 3, and shown in Fig. G of the text as already described. In order to secure a focus by which the cell processes could be seen even faintly the nucleus and nucleolus are almost entirely out of the plane of focus, the latter showing faintly however. Immediately about the nucleolus there is a slightly pale area, a portion of the nucleus. The contents of this cell-body itself present for the most part the appearance of a very dark, almost homogenous, intensely stained chromatic substance, and gives only a partial idea of the real structure and arrangement of the granules as seen in Fig. G. The contour of the nucleus cannot be distinctly made out, nor the relative position of the nucleolus in the same. The individual chromophilic granules cannot be distinguished excepting at the base of the right lateral dendritic process. The apical dendritic process appears as a mere shadow, owing to its being out of the plane of focus. The basal dendritic process show almost as well as in Fig. G, excepting the branching of the one at the left which is but faintly indicated. The small mass of chromatin at this point—the so-called "wedge of division," of Nissl—is also but faintly indicated. The general contour of the cell, points from which the dendritic processes are given off, and position of the nucleolus are accurately represented. Had a plane been selected showing the nucleus accurately some of the processes would have been entirely out of focus. Other cells adjacent to the one just described are seen to be less deeply stained and the chromatin is seen in the form of larger and smaller indistinctly rounded or elongated granules. It will thus be seen that there are limitations, and serious limitations too, in the use of photomicrographs, especially under high powers, in such a study as this. It would require several photomicrographs at various planes to bring out

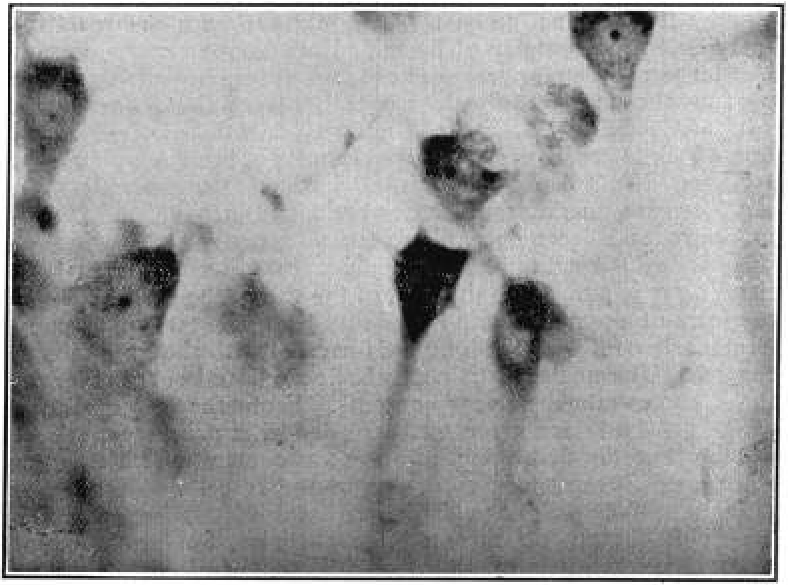


Plate II, Fig. 4.

all the details shown in the single Fig. G, which of course is a composite taken by focussing in all planes under a magnification of 1,300 diameters, and showing certain, but not all, details of the different planes. Of course outlines are not so distinct in the real cell as must necessarily be made to appear in a drawing, and this latter might be compared to a dissection in which certain parts are brought out prominently at the expense of the normal appearance of the whole in life. No one would hesitate to say, however, that Fig. G gave a much better idea though not an exact representation of the cell, than Plate II, Fig. 4, and that drawings are essential accompaniments of such plates in the full elucidation of a subject of this kind. These cells are known as stichocrome nerve cells of the somatochrome class. Fig. H shows one of the large pyramidal cells (the largest to be seen in the plate) under the same magnification as in Fig. G (x 1,300. No. 3 ocular, 1-12 in. oil immersion objective, Leitz). The internal structure of the large pyramidal cells is found to be made up of distinctly stained chromophilic substance in larger and smaller irregular granules, some so fine and closely arranged as to completely fill up the cell-body, thus presenting a uniform field of closely packed minute granules without any special relation to one another. In other cells the granules are coarser and present a somewhat parallel arrangement about the nulceus and extending up into the main apical process for some distance and also into the basal lateral processes in the same general parallel manner. In other pyramidal cells there is a fine chromophilic network with larger and smaller aggregations of chromatin as nodes or enlargements of the network. In this figure the cell-body is pyramidal in shape with rounded contour merging above into the large apical dendritic process, which is finally lost to view as it enters another plane. Below at the base, both to the right and left, are given off several dendritic processes, some of which are seen to branch a short distance from the cell-body. The large, slightly oval nucleus is centrally situated somewhat nearer the base of the cell than the apex, and contains a large, eccentrically placed nucleolus, surrounded by the pale, slightly strained, for the most part homogenous, nuclear protoplasm. Within the cell-body about the nucleus and extending into the apical process, and to a less extent into the basal dendritic processes, are chromophilic granules of rounded or elongated shape, and having a tendency to be arranged in groups in places. Especially at the point where a dendritic process is given off is frequently to be found a mass of these granules. Often a wedge or cap of chromophilic substance is seen at the point where a dendritic process is to be given off, as at *a*, or where a process divides into two branches, as at *b,* the latter being one of the so-called "wedges of division" of Nissl. The granules vary in size and shape and are arranged in general in a direction parallel to the long axis of the cell-body and of the long axis of the dendritic process when extending into the same. About the nucleus they are often arranged parallel to its wall. Five dendritic processes are given off from the base of this cell, three of which are seen to divide into two branches each; at *b,* showing one of the so-called "wedges of division" of Nissl, referred to above. Plate II, Fig. 5 is a photomicrograph of this same cell indicated by the figure H in Plate II, Fig. 3, and already described and shown in Fig. H; here under a magnification of 1,400 diameters. The body of another somewhat smaller pyramidal cell is seen just behind the apical dendritic process of this cell and part of it almost in

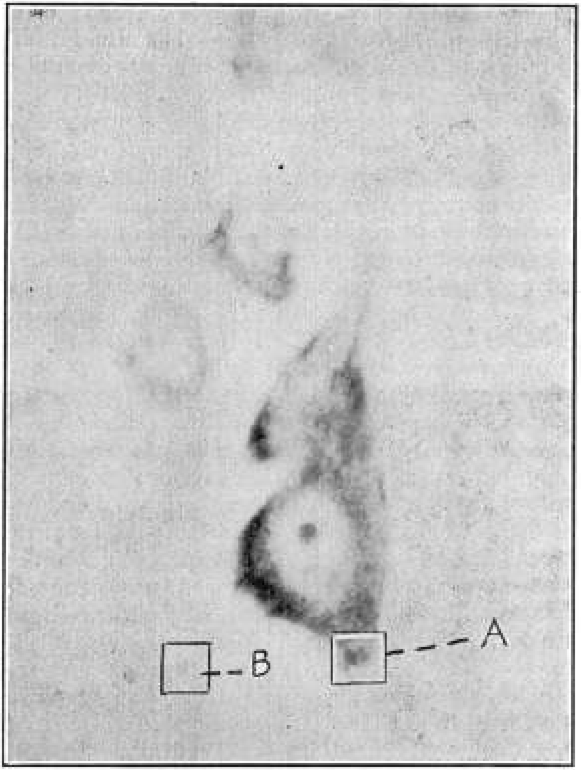


Plate II, Fig. 5.

the same place, so that it is difficult to differentiate the two. It will be seen that the nucleus and nucleolus are in good focus, but that the basal dendritic processes, excepting at their origin from the cell-body, can scarcely be distinguished. The shape of the nucleus, size and position of the nucleolus, and arrangement of the chromatin within the same is as well shown as in the figure. Also the shape and contour of the cell-body. The dendritic processes, however, as mentioned above, are out of the plane of focus, so that only a very hazy, indefinite indication of the beginning of three of them can be made out. The large one at the left can scarcely be determined at all. The more central one at the left is faintly outlined, and at the point of bifurcation the so-called "wedge of division" of Nissl (B) is seen, but the division itself cannot be determined. Of the three processes given off from the base at the right the beginning of the one most centrally located can be very faintly seen and a faint outline of the other two, appearing as one in the photomicrograph is seen. The apical dendritic process is so merged with the body of the cell just below it that it is difficult to determine its outline. The cell protoplasm is more differentiated however than in the preceding plate (Plate II, Fig. 4). Here chromophilic bodies are seen at the base on the right where the dendritic processes are given off, indicated by A both here and in Fig. H. Chromophilic granules are also seen fairly well indicated to the right and above the nucleus, in larger and smaller bodies without sharp outlines, which is the condition actually found in the cell. They are not sharply and definitely outlined as shown in Fig. H, which in that respect is not accurate, but merely diagrammatic. At the left and below the nucleus in the basal portion of the cell-body these chromophilic bodies are so closely aggregated as to give almost a homogenous dark appearance to that portion of the cell, and it is only by carefully focussing in various planes that the chromophilic bodies are made out. Here again the photomicrograph without the accompanying drawing would give one only a partial knowledge of the structure of this cell. Cells of this type are to be classified as large stichochrome nerve cells of the somatochrome class. Interspersed among these larger and smaller pyramidal cells in this layer are some small irregular and rounded cells consisting of a large nucleus containing a nucleolus, and surrounded by a cell-body containing in the smaller cells a very narrow rim of finely granular chromophilic substance, in some places so narrow as to be scarcely discernible. In other cells the cell-body is much more developed surrounding the nucleus and giving off several protoplasmic processes which go out in various directions. Neuroglia cells similar to those of the first layer are found interspersed among the nerve cells in all parts of the section. Small portions of capillary blood vessels are shown as at I in the plate (Plate II, Fig. 3, I) where the vessel is seen to divide into two branches below, and also at 2 (Plate II, Fig. 3, 2), showing a single small capillary extending only for a short distance in this plane. The walls are seen to be exceedingly thin, made up of a single layer of nucleated cells, and containing red blood corpuscles. The walls of these blood vessels stand in marked contrast to the thickened and tortuous walled vessels found in the cases of dementia paralytica later to be described. Below this is the third, or spindle cell layer about 1.20 mm. in thickness in this section. The spindle cells in this layer contain a large nucleus, with a distinct nucleolus, but no nuclear net work could be made out. The nuclei in many of them present the appearance of being too large for the cell-body, so that often, as in Fig. I, the cell-body seems to be bulged out on one side to accommodate the large nucleus, giving an eccentric form, and resulting in a spindle with one side very prominent and the opposite side quite flattened. The chromatic substance is arranged in no definite network and contains no distinct chromophilic bodies, but consists of minute particles closely aggregated about the nucleus, especially at each pole and found in a lesser amount and in variable quantities in the remainder of the cell-body. In Fig. J the nucleus is situated eccentrically at one end of the cell-body, so that most of the other cell contents are at the opposite end with a narrow band of closely aggregated chromophilic substance surrounding the nucleus at both ends. The nucleus in this cell is more elongated and oval in shape, with distinct nucleolus and otherwise pale, slightly stained contents. Other cells as Fig. K are more or less irregular in shape, in this case having the form of an irregular inverted pyramid containing a large rounded nucleus near the base which is surrounded by a narrow band of dense chromatic substance. About this is an irregular chromatic network containing nodal thickenings at some points. The nucleus contains a distinct nucleolus, but otherwise pale and but slightly stained contents. A large dendritic process is seen given off below and two dendritic process.go off from the base and to one side. Fig. L shows another irregular shaped cell with a dendritic process given off from one side in addition to those from each end. The large oval nucleus with distinct nucleolus and otherwise pale contents is centrally placed. Considerable chromatic substance is seen in the larger cell-body with distinct granules, forming an indistinct network at the point where the lateral dendritic process is given off, on the opposite side and also in the cell-body and at the base of each of the vertical processes. Plate III, Fig. 6, is a photomicrograph, at a magnification of 1,400 diameters, of a group of the spindle and irregular cells indicated by the letter I in Plate II, Fig. 3.

As will be noted, almost all the forms shown in the above described figures are to be seen here. The cell lettered I, is similar in shape and structure to that of Fig. I, including the bulging out of the nucleus to one side, and showing an aggregation of chromatic substance in the form of a nuclear cap at both poles of the nucleus. An irregular network of chromatin is seen within the nucleus surrounding the nucleolus. But little chromatic substance, in addition to the two nuclear caps above described, is to be seen in the small cell-body. Again the cell indicated by the letter J is very similar to that seen in Fig. J, the nucleus being at one end of the cell-body near the base of that polar dendrite. The nucleolus is situated at the lower portion and to the left in the nucleus and with but little faintly stained chromatic substance surrounding it. About the nucleus in the cell-body and extending into both dendritic processes is to be seen considerable chromatic substance arranged in an indefinite network. The cell lettered K is irregularly pyramidal

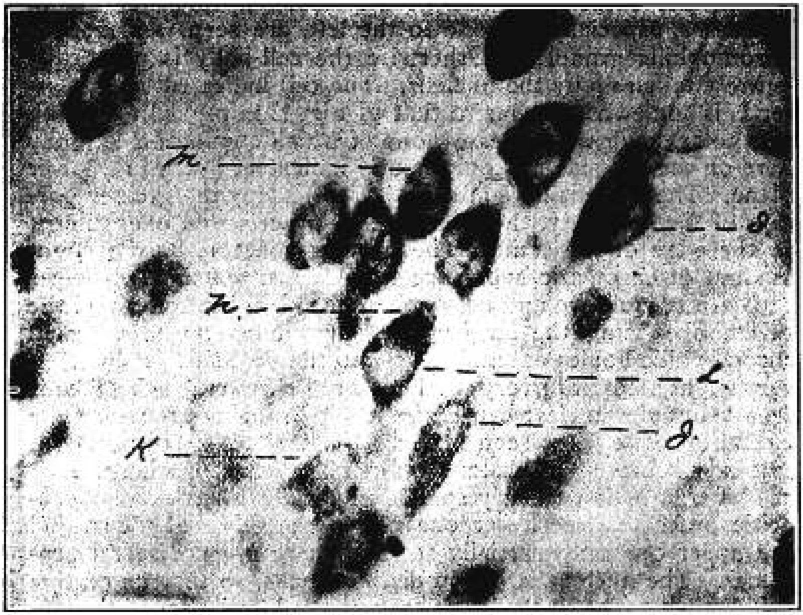


Plate III, Fig. 6.

in shape, approximating to that seen in Fig. K. The nucleus is very large and almost entirely fills up the cell-body. The nucleolus has the appearance of being without the nucleus, but is within the same adjacent to the wall at this point. A small amount of chromatin is seen in the lower part of the nucleus, otherwise it is for the most part pale. A process is seen given off above as the apical dendrite at the base of which are some few chromophilic granules.

Two basal dendritic processes are given off, one to the right and projecting almost vertically downward, and the other to the left and almost horizontal in direction. At the base of these processes, especially the one to the left, are seen well marked chromophilic granules. Otherwise the cell-body is practically entirely taken up by the nucleus. The cell indicated by the letter L is somewhat similar to that of Fig. L in regard to having two polar dendritic processes, one of which coming off laterally here on the left side and only faintly indicated, being in a lower plane. The nucleus here also is seen to occupy the greater portion of the cell-body, the nucleolus being crowded over almost to the edge of the same. The nucleus contains only a slight amount of chromatic substance in its upper portion. Nuclear caps are seen above and below the nucleus in the cell-body, the one above being the larger, and surrounded by some small chromophilic bodies extending up into the dendritic process. A very slight amount of very palely colored chromatic substance is seen below the nuclear cap in the lower dendritic process. The lateral dendrite when seen in focus is found to contain a slight amount of chromatic substance more abundant at the base. The cell lettered M is regularly spindle in shape with two polar dendritic processes, the lower one not in the plane of focus, and the upper one only partially so, and there are no lateral processes. The nucleus is not in distinct focus, so that its outline is indistinct. The nucleolus is seen at the lower part of the nucleus, and to the left side surrounded by a rather pale indefinite chromatic network. Below this is seen some dense chromatic substance in the form of a nuclear cap. The nucleus really occupies almost the entire body of this cell extending from the dark mass below which has the form of an irregular nuclear cap, to the base of the upper dendritic process where there is a smaller nuclear cap of chromatic substance. A small amount of protoplasm above and below the nucleus in the cell-body extends for a short distance into the dendritic process from these nuclear caps. The other cells seen in this plate are similar in appearance and structure to those already described.

(Plate illustrations referred to and not found will appear in the November issue.)

(*To be continued.*)